



Naval Fuels & Lubricants

Cross Functional Team

Test Report

Impact of 50% Synthesized Iso-Paraffins (SIP) on Middle Distillate Fuel Filtration and Coalescence

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EXECUTIVE SUMMARY

In October 2009, Secretary of the Navy Ray Mabus directed the Navy to decrease its reliance on fossil fuels. The Secretary set a goal of operating with at least 50% of energy consumption coming from alternative sources by 2020. He also set forth the goal of demonstrating a Great Green Fleet, operating on 50% alternative fuel, by 2012 and deploying by 2016. The use of alternative/petroleum sourced aviation fuel blends is a critical component to achieving these goals. The alternative sourced fuels will come from non-food sources and must be compatible with all existing hardware without compromising performance, handling or safety. The single-element test (SET) is required by SWP44FL-005: Naval Fuels and Lubricants Cross Functional Team (CFT) Shipboard Propulsion Fuel, F-76, Qualification Protocol for Alternative Fuel/Fuel Sources¹ to evaluate the compatibility of alternative sourced fuels with filter-separator systems currently in use by the fleet. During a SET, the alternative fuel is passed through a MIL-PRF-32148² qualified filter/coalescer and separator at 100% of the filter/coalescer element's rated flow rate. Over the span of the SET three contaminant conditions that may be seen during normal handling are tested—100 ppm by vol. free water, 72 mg/gal solid contaminant, and 3% by vol. free water. In order for a fuel to satisfactorily pass a SET, the alternative fuel must not impact the ability of filter-separators to decrease contaminant concentrations to below F-76 use limits as defined in Chapter 541 of the Naval Ships' Technical Manual³ or increase associated filter-separator maintenance. The SET evaluates the ability of filter/separators to remove solid contaminant levels of 72 mg/gal and free water levels as high as 3%. Additionally, the differential pressure across the filter-separator is measured to ensure no negative structural impacts.

An alternative sourced F-76 currently under-going qualification testing is Synthesized Iso-Paraffins (SIP). SIP fuels are made from direct fermentation of sugar into olefinic hydrocarbons. The olefinic hydrocarbons are hydroprocessed to produce an iso-paraffinic hydrocarbon. The Navy procured SIP that was 98% pure branched paraffin with a fifteen carbon chain called 2,6,10 trimethyldodecane or farnesane. Due to SIP's unique chemical composition and properties, SIP must be blended with traditional petroleum derived fuels in order to achieve full system and hardware compatibility.

A 50/50 F-76/SIP by volume blend was found to have no negative impacts on filter-separator performance. No effluent sample exceeded the filter-separator effluent free water and solid contaminant limits - 40 ppm by volume and 2.64 mg/L, respectively, established in Chapter 541 of the Naval Ships' Technical Manual. The maximum free water concentration measured was 9 ppm by volume and no sample exceeded a solid contaminant concentration of 0.4 mg/L. The average solid contaminant concentration measured during the solid injection phase was 0.11 mg/L. Over the duration of the test the differential pressure of the element increased from 2.0 psi with a new filter/coalescer element to 7.0 psi at the conclusion of testing. Based on these results, it is recommended that F-76 (derived from conventional material sources) and up to 50% SIP blends be approved for use with MIL-PRF-32148 qualified filter-separators. Due to similarities in test procedure for qualification of filter/coalescers to EI 1581 5th edition Category M type⁴, it is also recommended that F-76 (derived from conventional material sources) and up to 50% SIP blends be approved for use with EI 1581 5th ed. Category M type filter/coalescers.

LIST OF ACRONYMS/ABBREVIATIONS

CFT	Cross Functional Team
F-76	USN F-76 Grade Diesel Fuel
GPM	gallons per minute
NCT	Navy Coalescence Test
NSTM	Naval Ships' Technical Manual
PPM	parts per million by volume
SET	Single Element Test
SIP	Synthesized Iso-Paraffins

DEFINITIONS

Coalescence - the ability to shed water

Conventional Material Source - crude oil, natural gas liquid condensates, heavy oil, shale oil, and oil sands

Effluent - stream leaving a system

Influent - stream entering a system

Turnover - time required to flow the entire volume of fluid in a container, also known as residence time (volume of fuel ÷ volumetric flow rate)

Impact of 50% Synthesized Iso-Paraffins (SIP) on Middle Distillate Fuel Filtration and Coalescence

1.0 BACKGROUND

In October 2009, Secretary of the Navy Ray Mabus directed the Navy to decrease its reliance on fossil fuels. The Secretary set a goal of operating with at least 50% of energy consumption coming from alternative sources by 2020. He also set forth the goal of demonstrating a Great Green Fleet, operating on 50% alternative fuel by 2012 and deploying by 2016. The use of alternative/petroleum sourced aviation fuel blends is a critical component to achieving these goals. The alternative sourced fuels will come from non-food sources and must be compatible with all existing hardware without compromising performance, handling or safety. Qualification of alternative sources/process to produce F-76 is conducted in accordance with Navy SWP44FL-005: Naval Fuels & Lubricants Cross Functional Team (CFT) Shipboard Propulsion Fuel, F-76, Qualification Protocol for Alternative Fuel/Fuel Sources¹. Single Element Testing (SET) is a requirement under the full scale fuel system test section of the protocol.

An alternative sourced fuel currently under-going qualification testing is Synthesized Iso-Paraffins (SIP). SIP is made from direct fermentation of sugar into olefinic hydrocarbons. The olefinic hydrocarbons are hydroprocessed to produce an iso-paraffinic hydrocarbon. To represent this class of renewable fuel, the Navy procured SIP that was a 98% pure branched paraffin with a fifteen carbon chain called 2,6,10 trimethyldodecane or farnesane. Due to SIP's unique chemical composition and properties, it must be blended with traditional petroleum derived fuels in order to achieve full system and hardware compatibility.

Filter-separators are used onboard naval vessels (required onboard gas turbine ships and some diesel engine ships) and at shore stations to reduce solid and free water contamination to acceptable levels. As specified in F-76 specification MIL-DTL-16884N: Fuel Naval Distillate, the maximum allowable level of solid contamination in F-76 grade fuel at procurement is 10 mg/L. Chapter 541 the Naval Ships' Technical Manual (NSTM)³ establishes limits of a maximum free water concentration of 40 ppm and a maximum solid contaminant concentration of 2.64 mg/L at the outlet of shipboard filter-separators.

The SET evaluates the compatibility of alternative sourced fuels with filter-separator systems currently in use by the fleet. During a SET, the alternative fuel is passed through a separator and a MIL-PRF-32148² qualified filter/coalescer at 100% of the filter/coalescer element's rated flow rate. Over the span of the SET three contaminant conditions that may be seen during normal handling are tested—100 ppm by vol. free water, 72 mg/gal solid contaminant, and 3% by vol. free water. In order for a fuel to satisfactorily pass a SET, the alternative fuel must not impact the ability of filter-separators to decrease contaminant concentrations to below F-76 use limits as defined in Chapter 541 of the Naval Ships' Technical Manual³ or increase associated filter-separator maintenance. The latter requirement is addressed by measuring the differential pressure across the filter-separator.

2.0 OBJECTIVE

The objective of this test, in accordance with Navy SWP44FL-005: Naval Fuels & Lubricants CFT Shipboard Propulsion Fuel, F-76, Qualification Protocol for Alternative Fuel/Fuel Sources, was to determine the effects of SIP on filter-separator performance when present in F-76 at a concentration up to 50% by volume.

3.0 APPROACH

3.1 Test Fuel

The 50/50 F-76/SIP by volume blend used in this testing met all the physical and chemical properties defined in MIL-DTL-16884N (Appendix A). The F-76 used in this fuel blend was derived from conventional material sources. No additives were added or removed from the test fuel. The 50/50 F-76/SIP test fuel was stored in an epoxy lined aboveground storage tank until the time of testing. Prior to the start of testing, the tank's sump was drained of any water bottoms and the test fuel was filtered through a filter-separator housing until clean (solid contaminant concentration <0.26 mg/L and free water concentration <5 ppm).

3.2 Test Overview

Testing was conducted in accordance with Appendix C-2 of SWP44FL-005 Version 2.2. Per SWP44FL-005, the test outlined in MIL-PRF-32148 Section 4 was followed to complete the SET. This test procedure is also identical to EI 1581 5th edition⁴ Section 4.3 for Type S filter-separators with the exception that no additives were added to the test fuel prior to testing. These test conditions are summarized in Table 1. A five minute transition period between each phase is excluded from Table 1.

Table 1. Test Overview

Test Condition	MIL-PRF-32148	EI 1581 5 th Ed.	Duration, minutes	Sampling Interval	Contaminant Level
Element Conditioning	4.6.3.1	4.3.2.4.2	30	N/A	No Contaminant Added
Water Injection	4.6.3.2	4.3.2.5.1	30	At 0, 5, 10 ^{s/s} , 20 ^{s/s} , and 30 ^{s/s} minutes	100 ppm Free Water, no solid contaminant
Solids Injection	4.6.3.3	4.3.2.6.1	75	Every 15 minutes before and after stop/start	72 mg/gal solid contaminant, no Free Water
Water Injection	4.6.3.4	4.3.2.7.1	150	At 0, 2, 5, 15, 30 ^{s/s} , 45, 60 ^{s/s} , 75, 90 ^{s/s} , 105, 120 ^{s/s} , 135, and 150 ^{s/s} min	100 ppm Free Water, no solid contaminant
Water Injection	4.6.3.5	4.3.2.7.2	30	At 2, 5, 10 ^{s/s} , 20 ^{s/s} , and 30 minutes	30,000 ppm Free Water, no solid contaminant
Filter Inspection	-	4.3.2.8	Post-Test	-	-

^{s/s} Measurements made after a stop/start flow interruption. A stop/start procedure is achieved by shutting and then immediately opening a valve downstream of the test housing within 4 seconds.

A schematic of the test rig can be found in Appendix B. For this test, a Velcon Filters Inc. test housing was used. One 20 inch long by 6 inch O.D Velcon I-620MM coalescer element conforming to MIL-PRF-32148 (listed on MIL-QPL-32148⁵) and one TE01-87 Velcon Filters Inc. separator were used. The total flow rate through the test housing was 100% of the maximum rated capacity of the filter/coalescer, 15 gallons per minute.

The addition of 100 ppm and 30,000 ppm water was achieved by injecting 6 mL/min and 0.5 gpm of water, respectively. To ensure sufficient mixing, the water was injected upstream of a centrifugal pump having a rotational speed of 2,500 RPM. Due to the dark color of the test fuel which dyed the free water detector pads, the concentration of free water in the effluent stream could not be determined directly using ASTM method D3240: Standard Test Method for Undissolved Water in Aviation Turbine Fuel⁶. Instead, the free water concentration was calculated as the difference between the total water content of the test fuel and the total water content of the saturated fuel. The total water content was measured per ASTM D6304: Standard Test Method for Determination of Water in Petroleum Products, Lubricating Oils, and Additives by Coulometric Karl Fischer Titration⁷. Fuel samples were extracted with Hamilton GASTIGHT[®] glass syringes directly from the fuel system via in-line septums. Prior to collecting a test sample the syringe was flushed three times. The saturation point of the test fuel was determined in accordance with the test procedure described in Appendix C.

The solids injection rate of 72 mg/gal was attained by injecting the test fuel with a concentrated fuel and dirt slurry. A 10% by weight Copperas Red Iron Oxide R-9998 and 90% by weight Arizona A1 Ultrafine Test Dust ISO 12103-1 mixture was used as the solid contaminant. The concentrated slurry was injected upstream of the filter-separator housing. The solid concentration of the fuel was measured per ASTM D2276: Standard Test Method for Particulate Contaminant in Aviation Fuel by Line Sampling⁸.

Due to limited tank availability, a single pass of the test fuel through the test housing was not possible. The risks associated with recirculating the fuel such as introduction of additional contamination were mitigated by filtering the fuel through an additional filter-separator housing prior to the fuel returning to the supply tank in addition to using 10,000 gallons of test fuel. The total volume of fuel used during this test represents less than 0.5 turnovers of the 10,000 gallons in the supply tank.

3.3 Acceptance Criteria

Per Navy SWP44FL-005¹ and MIL-PRF-32148², the differential pressure across the element in combination with the separator stage shall not exceed 6 pounds per square inch (psi) at 100 percent rated flow when using a fuel containing less than 0.26 mg/L solids and 5 ppm free water. During the solids injection phase, the differential pressure across the element at rated flow shall not be greater than 15 psi before 50 minutes and 45 psi before 75 minutes.

The average weight of solids in the effluent fuel samples shall not be greater than 2.64 mg/L and the weight of solids in any single sample shall not be greater than 5.0 mg/L. The free water concentration in the effluent fuel samples shall be less than 40 ppm. These contaminant requirements align with filter-separator effluent line limitations outlined in Table 541-10-3 of NSTM Chapter 541.

4.0 DISCUSSION

4.1 Free Water Impacts

At no point during the test did the free water concentration in the effluent sample exceed 40 ppm free water (by vol.). The free water concentration was calculated based on the test fuel's water saturation point at 75°F, 61 ppm (see Appendix C). The water saturation point of the test fuel at 75°F is a reasonable estimate of the water saturation point of the fuel during the SET because the temperature of the fuel varied between 72°F and 78°F. Any variations in water saturation point due to temperature differences over this range would be indiscernible due to the reproducibility of ASTM D6304 (9 ppm by volume for measured total water content of 61 ppm). Additionally, 61 ppm is within ± 2 ppm of the water saturation point measured during the 50/50 F76/SIP Navy Coalescence Test (NCT)⁹. The total water concentration of the influent and effluent fuel streams can be found in Figure 1. Influent total water concentrations measured during the 3% (30,000 ppm) water injection test phase are excluded from Figure 1 due to scaling but can be found along with all other test data in Appendix D. An average of 2.9% total water was measured in the influent stream. The calculated free water concentration of the effluent stream can be found in Figure 2. Error bars corresponding to the 95% confidence interval, per section 17.1.1 Repeatability of ASTM D6304, are included in Figure 1. Dashed vertical lines are also included in each figure to differentiate between the test phases (see Table 1). As can be seen in Figure 2, the maximum free water concentration measured was 9 ppm during the 3% water injection test phase. Therefore, 50/50 F76/SIP satisfactorily met the free water requirement stated in Section 3.3 of this test report.

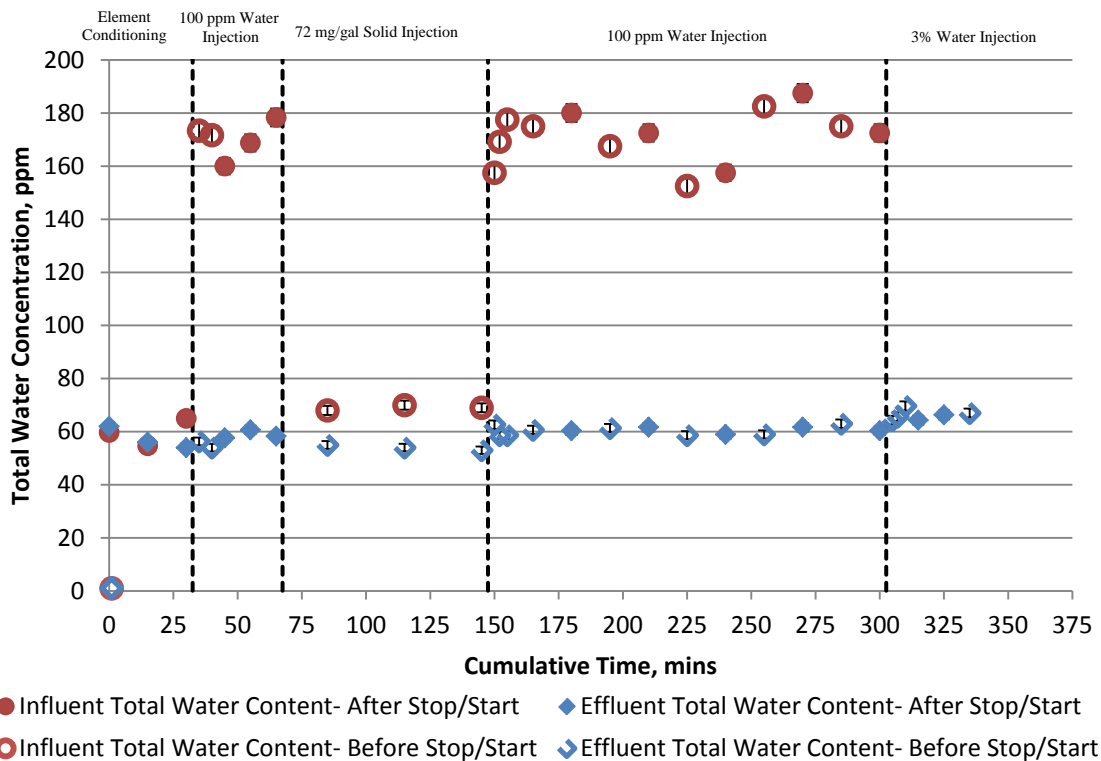


Figure 1. Influent and Effluent Total Water Concentration

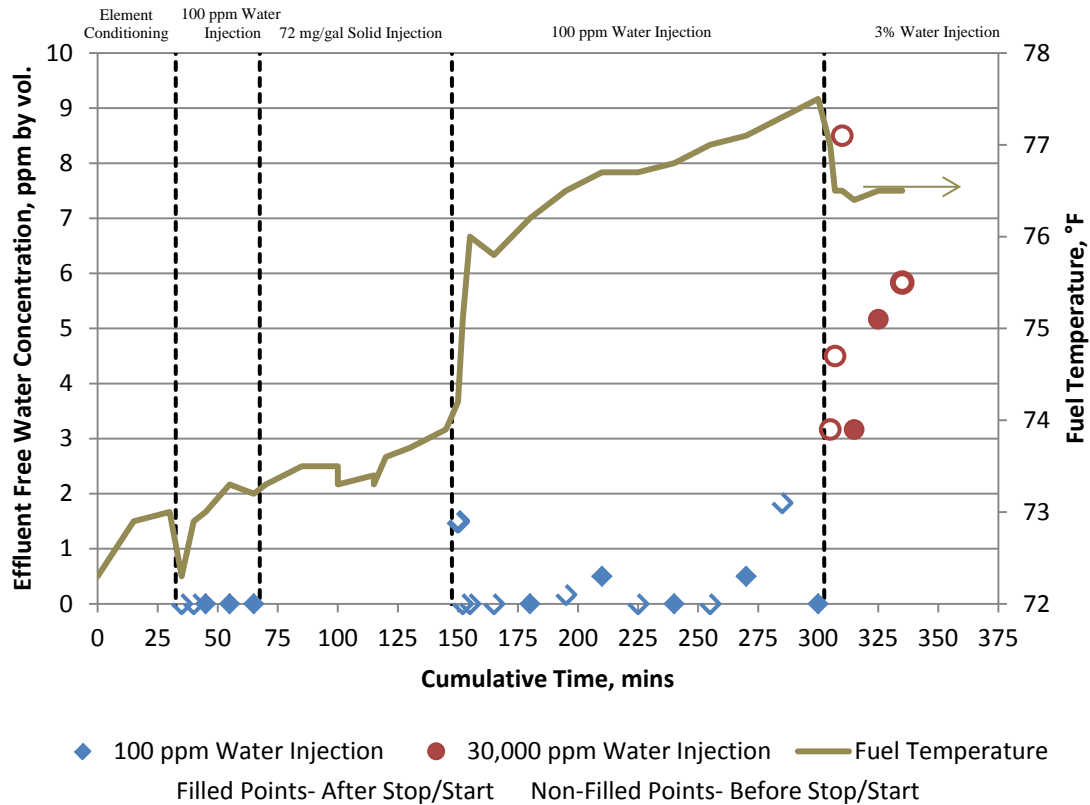


Figure 2. Calculated Effluent Free Water Concentration

4.2 Sediment Contamination

The results from the solid holding phase of testing can be found in Figure 3. The average concentrations of solids measured in the influent and effluent fuel streams during the solids holding phase were 77 mg/L and 0.11 mg/L, respectively. An average of 0.12 mg/L and 0.09 mg/L solid contaminant were measured before and after performing a stop/start, respectively. The overall, before stop/start and after stop/start average solid concentrations were below the 2.64 mg/L limit stated in Section 3.3. The maximum solid contaminant concentration measured was 0.40 mg/L, far below the 5.0 mg/L limit stated in Section 3.3. These results show that the alternative fuel component, SIP, has no negative impact on the ability of filter/coalescers to remove and retain solid contaminant.

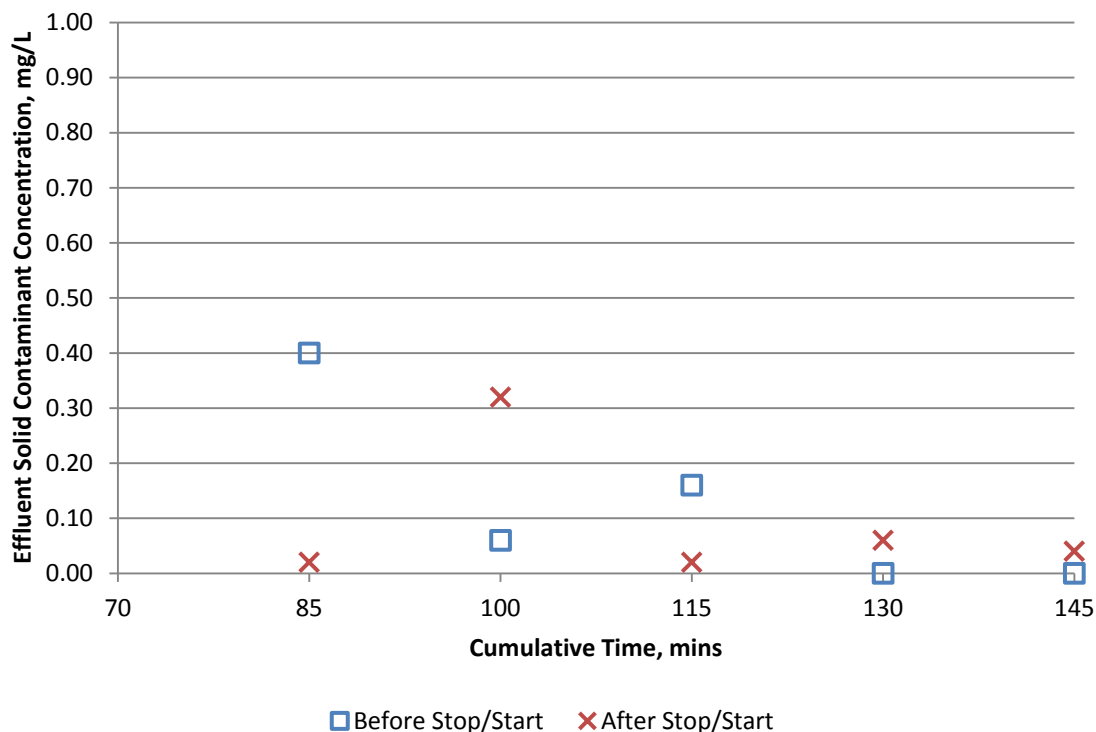


Figure 3. Effluent Particulate Contamination

4.3 Filter-Separator Differential Pressure

The differential pressure across the filter-separator housing satisfactorily met all of the differential pressure requirements stated in Section 3.3. Over the span of the SET, the differential pressure across the filter-separator increased from 2 psi at beginning of testing to 7 psi at the completion of the 3% water injection test phase. 50/50 F76/SIP satisfactorily met the differential requirements stated in Section 3.3 of this test report.

5.0 CONCLUSIONS

50/50 F-76/SIP fuel blends met all solid/water removal and differential pressure performance criteria as stated in section 3.3 of this test report and defined in Table 541-10-3 of NSTM Chapter 541 and MIL-PRF-32148, respectively.

6.0 RECOMMENDATIONS

It is recommended that F-76 (derived from conventional material sources) and SIP fuel blends up to 50% SIP be approved for use with EI 1581 5th edition Category M and MIL-PRF-32148 qualified filter-separators.

7.0 REFERENCES

1. United States Navy- Naval Fuels & Lubricants CFT. *SWP44FL-005: Naval Fuels & Lubricants CFT Shipboard Propulsion Fuel, F-76, Qualification Protocol for Alternative Fuel/Fuel Sources*
2. U.S. Department of Defense. *MIL-PRF-32148 Performance Specification Filter-separator Elements, Fluid, Pressure, Aviation and Distillate Fuel, Naval Shipboard*, July 2005
3. U.S. Department of Defense. *Naval Ships' Technical Manual Chapter 541 Revision 5*, August 2007
4. Energy Institute. *EI 1581 5th Edition Specifications and Qualification Procedures For Aviation Jet Fuel Filter-separators*, July 2002
5. U.S. Department of Defense. *MIL-QPL-32148: Filter-separator Elements, Fluid, Pressure, Aviation and Distillate Fuel, Naval Shipboard.*, April 2010
6. ASTM International. *ASTM D3240-11: Standard Test Method for Undissolved Water in Aviation Turbine Fuel*, March 2011
7. ASTM International. *ASTM D6304-07: Standard Test Method for Determination of Water in Petroleum Products, Lubricating Oils, and Additives by Coulometric Karl Fischer Titration*, August 2007
8. ASTM International. *ASTM D2276-06: Standard Test Method for Particulate Contaminant in Aviation Fuel by Line Sampling*, July 2014
9. United States Navy- Naval Fuels & Lubricants CFT. *Impact of 50% Synthesized Iso-Paraffins (SIP) on F-76 Fuel Coalescence*, December 2013

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APPENDIX A. CHEMICAL AND PHYSICAL PROPERTIES

Conformance to F-76 Chemical and Physical Properties per MIL-DTL-16884N

Table A-1. 50/50 F76/SIP Certificate of Analysis

Test (Units)	Method	Minimum	Maximum	Fuel
Appearance at 25°C	D4176	Clear & Bright		Clear & Bright
Demulsification at 25°C (minutes)	D1401		10	4
Density at 15°C (kg/m ³)	D4052	800	876	821
Distillation	D86			
10% Recovered (°C)		Report		236
50% Recovered (°C)		Report		252
90 % Recovered (°C)			357	297
End Point (°C)			385	339
Reside + Loss (volume %)			3.0	1.4
Cloud Point (°C)	D5773		-1	-32
Color	D6045		3	1
Flash Point (°C)	D93	60.0		91.0
Particulate Contamination (mg/L)	D5452		10	0 ^{/1}
Pour Point (°C)	D5949		-6	-54
Viscosity at 40°C (mm ² /s)	D445	1.7	4.3	3.2
Acid Number (mg KOH/g)	D974		0.30	0.05
Ash (mass %)	D482		0.005	0.000
Aromatics (mass %)	D6591	8.1 ^{/2}		11.8
Carbon Residue on 10% Bottoms (mass %)	D524		0.20	0.12
Copper Strip Corrosion at 100 °C	D130		1	1a
Hydrogen Content (mass %)	D7171	12.5		13.9
Ignition Quality	D6890	42		54
Storage Stability, Total Insolubles (mg/ 100mL)	D5304		3.0	1.0
Sulfur Content				
XRF(mass %), or	D4294		0.0015	0.0171
UV Fluorescence (mg/kg)	D5453		15 ^{/3}	-
Trace Metals (mg/kg)	D7111			
Ca			1.0	0.0
Pb			0.5	0.1
Na + K			1.0	0.2
V			0.5	0.1
Lubricity ^{/4} (µm)	D6079		460	450

^{/1} Measured directly prior to testing

^{/2} Requirement applies to only fuels containing synthetic blending components

^{/3} This ultra-low sulfur requirement is waived until all diesel fuels are able to meet this requirement. Sulfur content for all diesel fuels must be less than 1000 mg/kg.

^{/4} Requirement applies only to fuels containing less than 500 ppm sulfur and/or synthetic blending components.

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APPENDIX B. TEST RIG SCHEMATIC

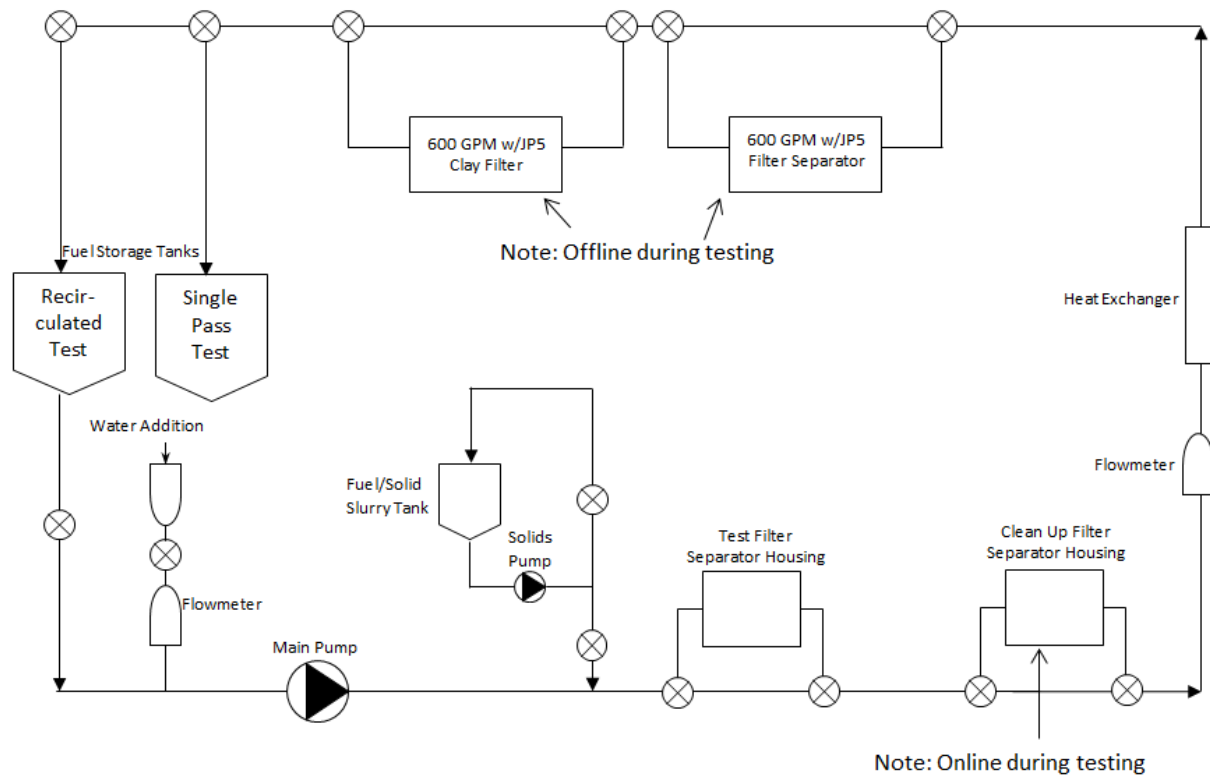


Figure B-1. Test Rig Schematic

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APPENDIX C. WATER SATURATION TEST PROCEDURE

Scope: This procedure can be used to evaluate water solubility in aviation and diesel fuels.

Required Instrumentation and Equipment:

- 125 mL glass bottles
- Water Bath (or equivalent temperature chamber)
- Karl Fischer test instrument (per ASTM D6304)
- Transfer Syringe
-

Fuel Required: 100 mL of test fuel.

Required Reagents & Materials:

Deionized water

Test Procedure:

1. Add 25 mL of deionized water and 75 mL of 50/50 F76/SIP to a 125 mL glass bottle. Cap the bottle and place the sample in a temperature chamber set to 75°F. Repeat this procedure for an additional 3 sample vials.
2. Maintain the samples at test temperature for 24 hours.
3. The amount of water in the fuel layer shall be determined using ASTM D6304, Procedure A. Draw a 1 mL aliquot of the sample, using a transfer syringe, from the middle of the fuel layer for the test. Determine total water content immediately while the fuel sample is at the test temperature. Repeat this procedure until three measurements have been made for all four sample vials.

Results:

Table C-1. 50/50 F76/SIP Water Saturation Point Results

Sample #	Repetition		
	1	2	3
1	67	50	53
2	65	50	54
3	73	64	62
4	71	61	64

Conclusion:

The saturation point of the SET alternative fuel (50/50 F76/SIP) at 75°F is 61 ppm by volume (average of 4 samples).

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APPENDIX D. TEST DATA

Table D-1. Test Results

Phase	Cumulative Time, min	Fuel Flow Rate, gpm	Temp, °F	ΔP, psi	k, pS/m	Influent Total Water Conc, ppm	Effluent Total Water Conc, ppm	Free Water Conc, ppm	Influent Solids Conc, mg/L	Effluent Solids Conc, mg/L
Element Conditioning	0	14.56	72.3	2	5	60	62	1	0.02	
	15	14.56	72.9	2		55	56	0		
	30	15.17	73	2	4	65	54	0		
Low Water Coalescence, 100 ppm	35	15.17	72.3	2	6	173	56	0		
	40	14.56	72.9	2		172	54	0		
	45 s/s	14.56	73	2		160	58	0		
	55 s/s	14.56	73.3	2		169	61	0		
	65 s/s	15.17	73.2	2	4	178	58	0		
Solids Holding, 72 mg/gal	70	14.56	73.3	2.5	5				20.45	
	85	14.56	73.5	2.5		68	55	0		0.4
	85 s/s	14.56	73.5	2.5						0.02
	100	14.56	73.5	2.5	5				23.9	0.06
	100 s/s	14.56	73.3	2.5						0.32
	115	14.56	73.4	3		70	54	0		0.16
	115 s/s	14.56	73.3	3						0.02
	120	14.56	73.6	3						
	130	14.56	73.7	3	4				15.5	0
	130 s/s	15.17	73.7	3						0.06
	145	14.56	73.9	3		69	53	0		0
	145 s/s	14.56	73.9	3						0.04

s/s= measurement taken after stop/start flow interruption

Table D-1. Test Results (Continued)

Phase	Cumulative Time, min	Fuel Flow Rate, gpm	Temp, °F	ΔP, psi	k, pS/m	Influent Total Water Conc, ppm	Effluent Total Water Conc, ppm	Free Water Conc, ppm	Influent Solids Conc, mg/L	Effluent Solids Conc, mg/L	
Low Water Coalescence, 100 ppm	150	14.56	74.2	3	4	158	63	2			
	152	14.56	75.1	3		169	59	0			
	155	14.56	76	3		178	59	0			
	165	14.56	75.8	3	4	175	61	0			
	180 s/s	14.56	76.2	3		180	60	0			
	195	14.56	76.5	3		168	61	0			
	210 s/s	14.56	76.7	3	4	173	62	0			
	225	15.17	76.7	3.5		153	59	0			0
	240 s/s	14.56	76.8	3.5		158	59	0			
	255	15.17	77	3.5	5	183	59	0			
	270 s/s	14.56	77.1	4		188	62	0			
	285	14.56	77.3	4		175	63	2			0
	300 s/s	14.56	77.5	4		173	60	0			
High Water Coalescence, 3%	305	14.56	77	4	5		64	3			
	307	14.56	76.5	6			66	5			
	310	14.56	76.5	6.5			70	9			
	315	14.56	76.4	6.5	5		64	3			
	325	14.56	76.5	7			66	5			
	335	15.17	76.5	7	5		67	6			

s/s= measurement taken after stop/start flow interruption

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14. ABSTRACT In October 2009, Secretary of the Navy Ray Mabus directed the Navy to decrease its reliance on fossil fuels. The objective of this test program is to ensure that all proposed alternative fuels perform equally or better than existing petroleum sourced fuels. An alternative sourced fuel currently under-going qualification testing is Synthesized Iso-Paraffins (SIP). The Navy procured SIP that was 98% pure branched paraffin with a fifteen carbon chain called 2,6,10 trimethyldodecane or farnesane. Qualification of F-76/SIP fuel blends is currently being conducted in accordance with Navy SWP44FL-005: Naval Fuels & Lubricants CFT Shipboard Qualification Protocol for Alternative Fuel/Fuel Sources. The single-element test (SET) is a SWP44FL-005 required full scale fuel system test whose purpose is to evaluate the compatibility of alternative sourced fuels with filter/separator systems currently in use by the fleet. The SET evaluates the ability of filter/separators to remove solid contaminant levels of 72 mg/gal and free water levels as high as 3%. Additionally, the differential pressure across the filter separator is measured to ensure no negative structural impacts. A 50%/50% F-76/SIP blend was found to have no negative impacts on filter/separator performance. No effluent sample exceeded the effluent free water or sediment concentration limits. It is recommended that F-76 (derived from conventional material sources) and SIP fuel blends up to 50% SIP be approved for use with EI 1581 5 th edition Category M and MIL-PRF-32148 qualified filter separators.				
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